The reliability of a semi-quantitative scoring method for taper corrosion and fretting, and its usefulness for predicting the volume of material loss

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Disclosures

(1) Institutional support from 9 companies

(contract allows freedom to publish all information)

(2) ORUK and The Furlong Foundation

(3) DePuy ASR retrieval Program:

(We are a contracted independent retrieval center)

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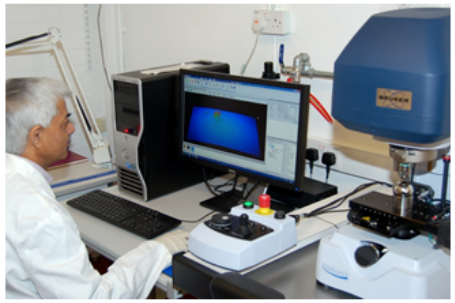

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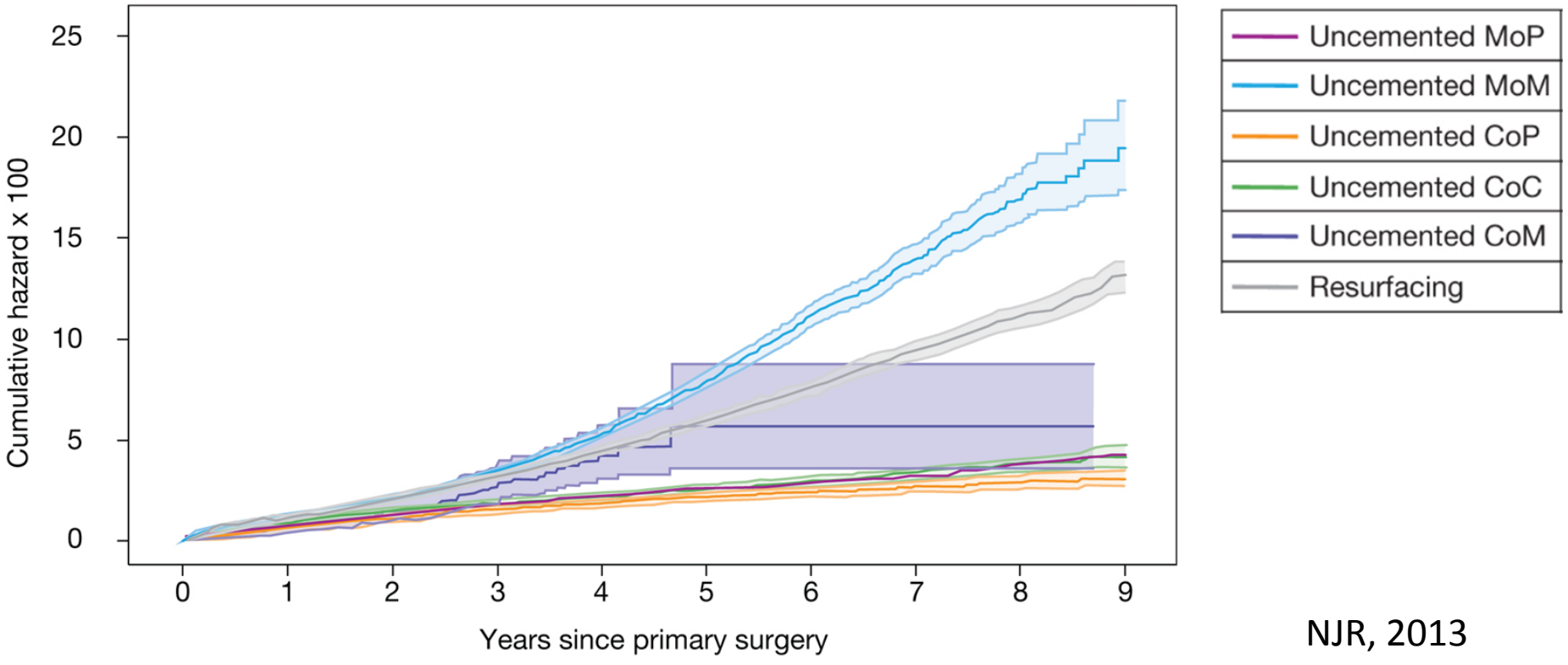
Background



NJR, 2013

- **High revision rates of LD-MOM-THAs increasingly reported.**
- **These revision rates are higher than equivalent resurfacings.**

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Background

- Multiple mechanisms may lead to differences in failure rates.
- Material loss at the head-stem taper junction may be significant.

- Material loss may be due to: - mechanical wear
  - corrosion
  - fretting

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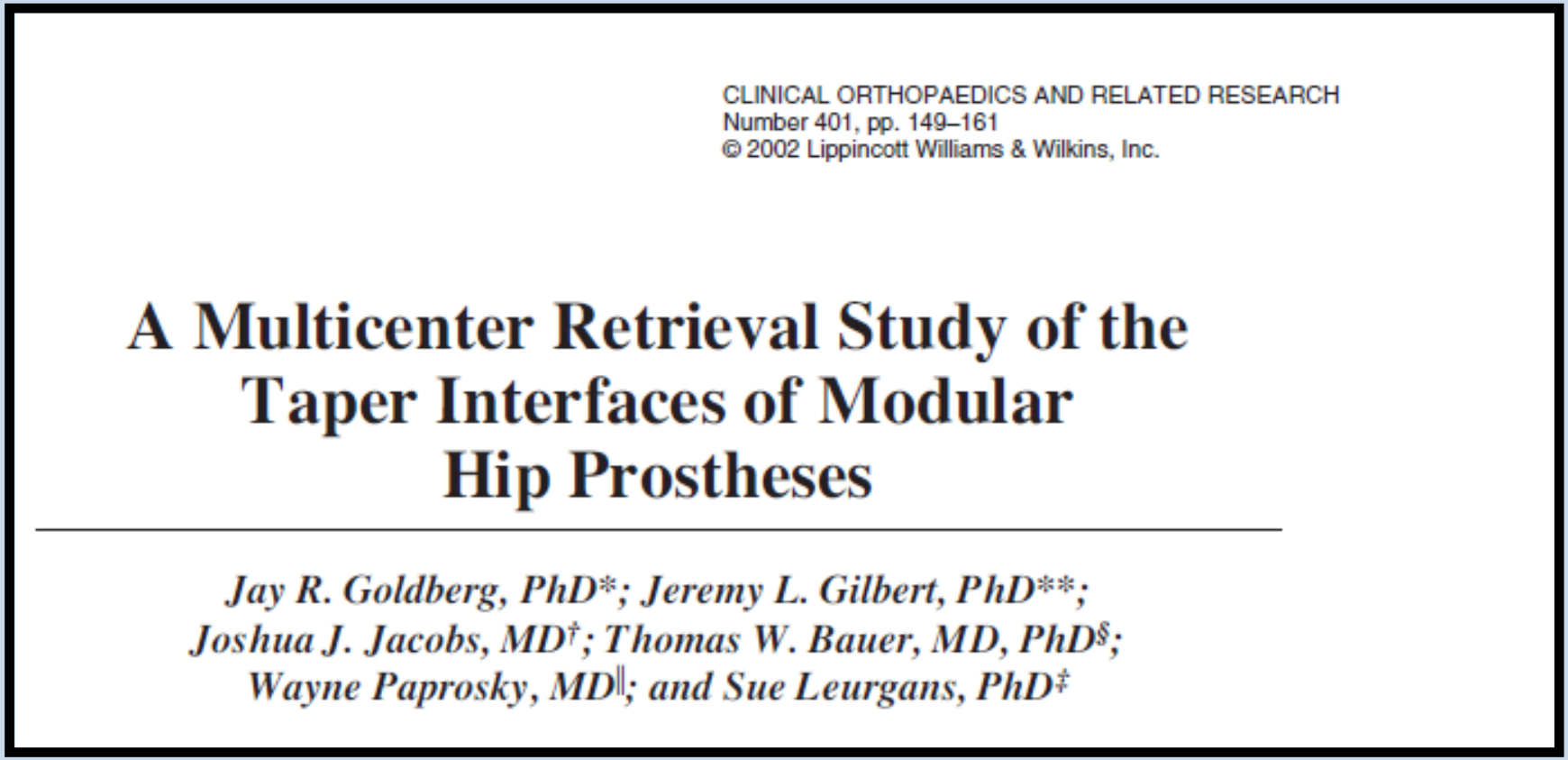
Corrosion and Fretting scoring



CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 401, pp. 149–161

A Multicenter Retrieval Study of the Taper Interfaces of Modular Hip Prostheses

Jay R. Goldberg, PhD; Jeremy L. Gilbert, PhD**; Joshua J. Jacobs, MD†; Thomas W. Bauer, MD, PhD§; Wayne Paprosky, MD‖; and Sue Leurgans, PhD‡*

- **Visual scoring system for the appearance of corrosion and fretting**
- **Used in numerous publications examining taper surfaces**

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Corrosion and Fretting scoring

Adverse Local Tissue Reaction Arising from Corrosion at the Femoral Neck-Body Junction in a Dual-Taper Stem with a Cobalt-Chromium Modular Neck

H. John Cooper, MD, Robert M. Urban, PhD, Richard L. Wixson, MD, R. Michael Meneghini, MD, and Joshua J. Jacobs, MD

Investigation performed at Rush University Medical Center and Northwestern University Feinberg School of Medicine, Chicago, Illinois, and Indiana University School of Medicine, Indianapolis, Indiana

Clin Orthop Relat Res
DOI 10.1007/s11999-013-3115-3

Clinical Orthopaedics and Related Research®
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SYMPOSIUM: 2013 HIP SOCIETY PROCEEDINGS

Taper Design Affects Failure of Large-head Metal-on-metal Total Hip Replacements

Nader A. Nassif MD, Danyal H. Nawabi MD, Kirsten Stoner MEng, Marcella Elpers BS, Timothy Wright PhD, Douglas E. Padgett MD

The Journal of Arthroplasty Vol. 24 No. 7 2009

Corrosion of a Hip Stem With a Modular Neck Taper Junction

A Retrieval Study of 16 Cases

Alan M. Kop, PhD, MSc, and Eric Swarts, BAppSc

LEVELS OF TAPER CORROSION AND WEAR IN 50 RETRIEVED ASR XL METAL–ON–METAL HIP COMPONENTS

A. Hexter, A. Panagiotidou, J. Singh, J. Skinner and A. Hart

The Journal of Arthroplasty 28 (2013) 1036–1040

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The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

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The Influence of Head Size on Corrosion and Fretting Behaviour at the Head-Neck Interface of Artificial Hip Joints

Richard M.R. Dyrkacz M.Sc. [a], Jan-M. Brandt PhD [a,b], Olanrewaju A. Ojo PhD [a], Thomas R. Turgeon MD [b], Urs P. Wyss PhD [a,b]

[a] *University of Manitoba, Department of Mechanical and Manufacturing Engineering, E2-327 Engineering and Information Technology Complex, 75A Chancellors Circle, Winnipeg, Manitoba, Canada R3T 2N2*
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Fretting and Corrosion Changes in Modular Total Hip Arthroplasty

Michael B Cross, Christina Esposito, Anna Sokolova, Reza Jenabzadeh, Dennis Molloy, Selin Munir, Bernard Zicat, William K Walter and William L Walter

Retrieval Analysis of Metal–on–Metal Total Hip Prostheses: Characterizing Fretting and Corrosion at Modular Interfaces

Genymphas Higgs, Steven Kurtz, Josa Hanzlik, Daniel MacDonald, William M Kane, Judd Day, Gregg Roger Klein, Jay Parvizi, Michael Mont, Matthew Kraay, John Martell, Jeremy Gilbert and Clare Rimnac

Taper Corrosion Update: What is the Role of Ceramic Femoral Ball Heads?

by Steven M. Kurtz, MD, PhD

Corrosion and Fretting scoring

Score	Corrosion Criteria	Fretting Criteria
1 (None)	No visible corrosion	No visible signs of fretting
2 (Mild)	<30% surface discoloured/dull	Band(s) for fretting scars across ≤3 machine lines
3 (Moderate)	>30% surface discoloured/dull or <10% containing black debris, pits or etch marks	Band(s) involving >3 machine lines on taper surface
4 (Severe)	>10% of surface containing black debris, pits or etch marks	Several bands of fretting scars involving several machine lines or flattened areas with nearby fretting scars

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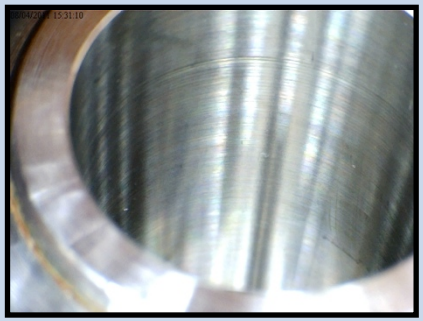
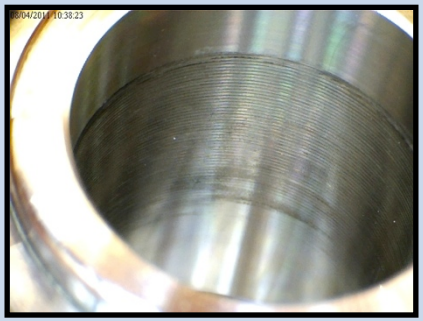
4 (Severe)	>10% of surface containing black debris, pits or etch marks	Several bands of fretting scars involving several machine lines or flattened areas with nearby fretting scars

Corrosion and Fretting scoring

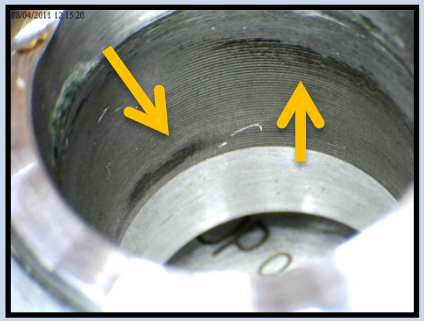
None (1)



Mild (2)



Moderate (3)



Severe (4)

Increasing severity of corrosion

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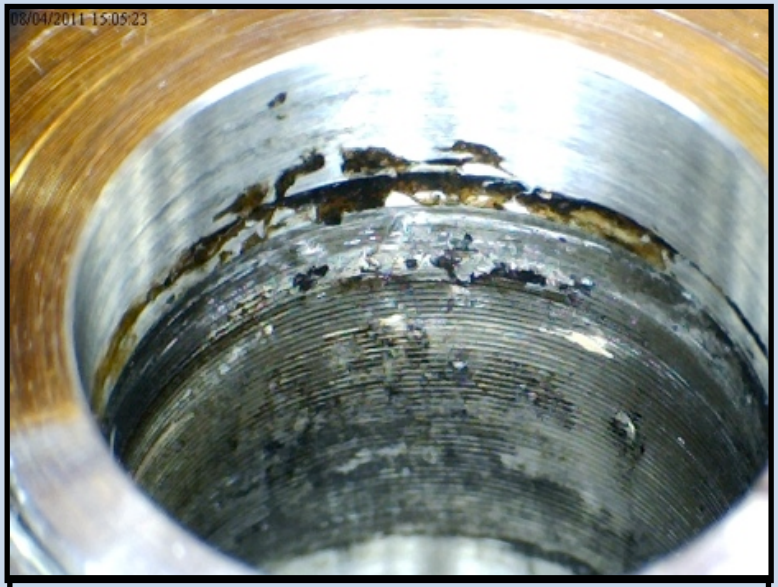
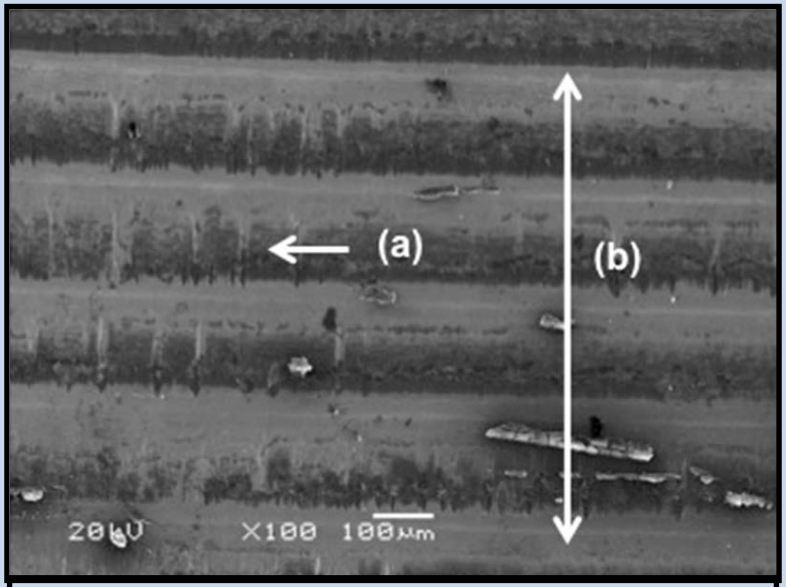
Corrosion and Fretting scoring



Large amount of discolouration and black deposits on head taper



SEM showing (a) fretting scars and (b) imprinting of stem taper screw thread

- **Metrology is gold standard but scoring is a quick method taper assessment.**
- **However the reproducibility of this system is unknown.**
- **Relationship between corrosion/fretting scores and taper material loss unclear.**

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Aims

1. What is the strength of the **reliability** and **repeatability** of visual taper corrosion and fretting assessments?

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Aims

1. What is the strength of the **reliability** and **repeatability** of visual taper corrosion and fretting assessments?

2. Is there a correlation between corrosion and fretting scores and the actual volume of material lost at the taper junction?

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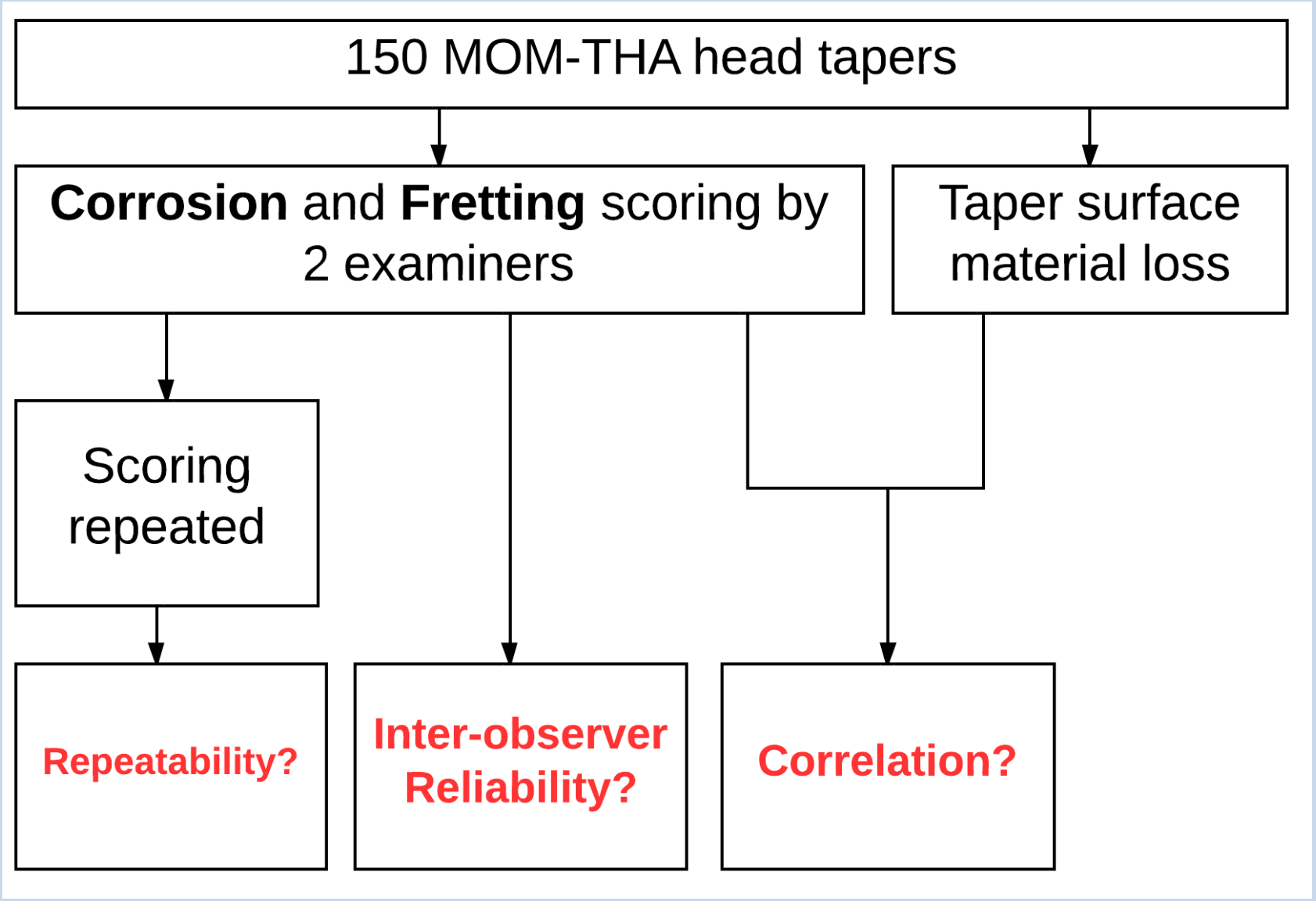
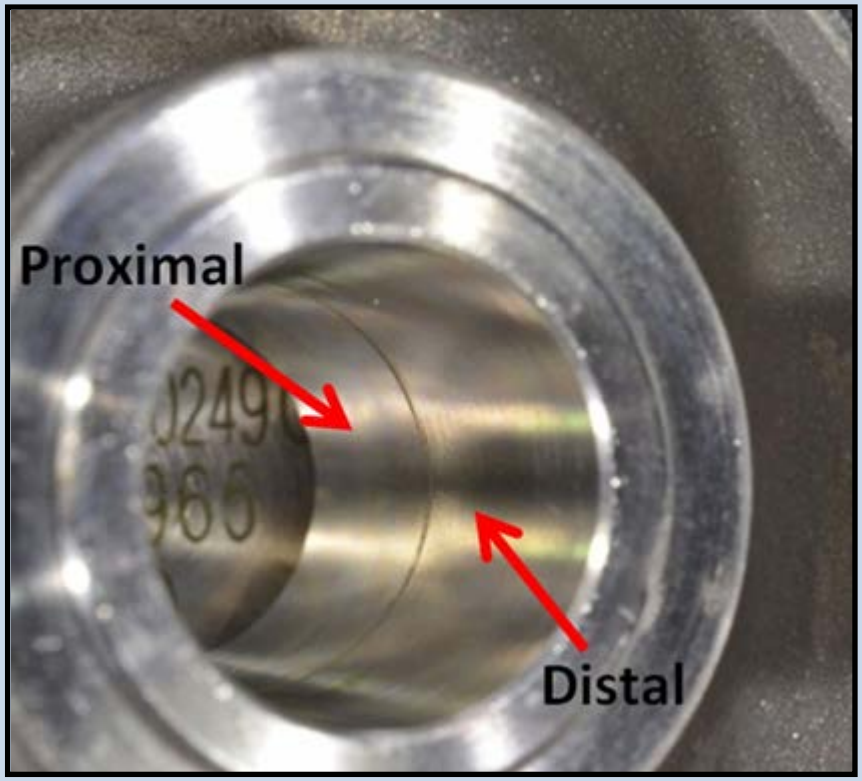
Methods



Methods



- Scores assigned to the proximal and distal halves of taper surface.
- Overall scores assigned following assessment of surface as a whole

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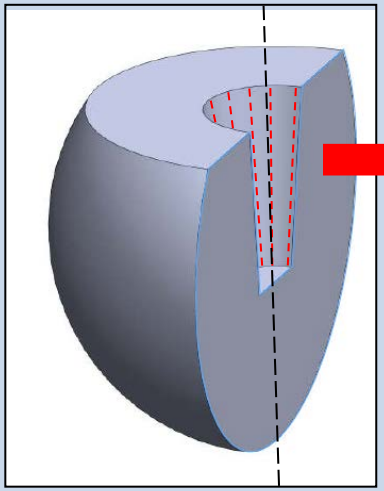
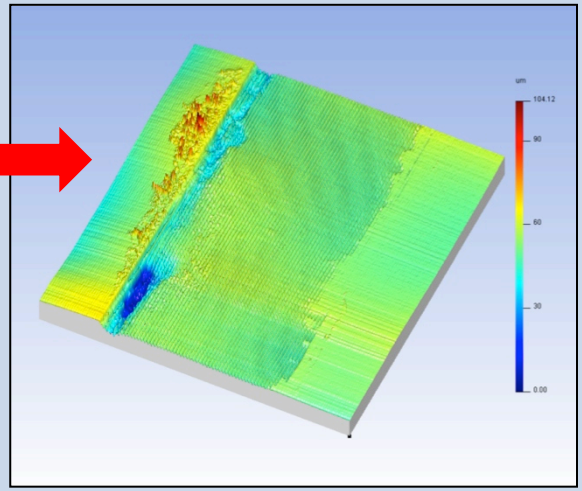
Methods

Taper surface material loss measurements

Roundness Measuring Machine (Taylor Hobson 365)

- 360 vertical traces
- 2.5 million data points





Bills PJ, Racasan R, Tessier P, Blunt LA. Assessing the material loss of the modular taper interface in retrieved metal-on-metal hip replacements [abstract]. 14th International Conference on Metrology and Properties of Engineering Surfaces, 2013.

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Methods

- Cohen's weighted Kappa statistic (κ) measures the repeatability and reliability of the scores.

Kappa Value	Repeatability /Reliability
≤ 0	poor
0.01 to 0.20	slight
0.21 to 0.40	fair
0.41 to 0.60	moderate
0.61 to 0.80	substantial
0.81 to 1	almost perfect

- The Spearman Rank test was used to determine the strength of correlation between the scores and the measured material loss.

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Results

1. What is the strength of the **reliability** and **repeatability** of visual taper corrosion and fretting assessments?

2. Is there a correlation between corrosion and fretting scores and the actual volume of material lost at the taper junction?

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Results

Inter-observer reliability

	Observed Agreement	Kappa	95% CI for Kappa
Corrosion Proximal	92%	0.52	0.42 to 0.66
Corrosion Distal	94%	0.70	0.45 to 0.69
Corrosion Overall	95%	0.64	0.52 to 0.73
Fretting Proximal	85%	0.14	0.01 to 0.46
Fretting Distal	84%	0.13	0.11 to 0.51
Fretting Overall	84%	0.18	0.14 to 0.51

- **Better observed agreement for all corrosion scores than fretting.**
- **The reliability of the corrosion scores was moderate to substantial.**
- **The reliability of the fretting scores was slight.**

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Results

Examiner repeatability

	Observed Agreement		Kappa		95% CI for Kappa	
	Examiner A	Examiner B	Examiner A	Examiner B	Examiner A	Examiner B
Corrosion Proximal	93%	91%	0.65	0.67	0.53 to 0.74	0.49 to 0.71
Corrosion Distal	95%	92%	0.77	0.69	0.69 to 0.84	0.70 to 0.83
Corrosion Overall	94%	95%	0.71	0.70	0.58 to 0.79	0.61 to 0.77
Fretting Proximal	89%	88%	0.25	0.21	0.10 to 0.40	0.04 to 0.37
Fretting Distal	88%	90%	0.33	0.28	0.18 to 0.47	0.17 to 0.44
Fretting Overall	89%	87%	0.31	0.27	0.16 to 0.452	0.11 to 0.41

- **Better observed agreement for all corrosion scores than fretting.**
- **The repeatability of the corrosion scores was substantial.**
- **The repeatability of the fretting scores was fair.**

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Results

1. What is the strength of the **reliability** and **repeatability** of visual taper corrosion and fretting assessments?

2. Is there a correlation between corrosion and fretting scores and the actual volume of material lost at the taper junction?

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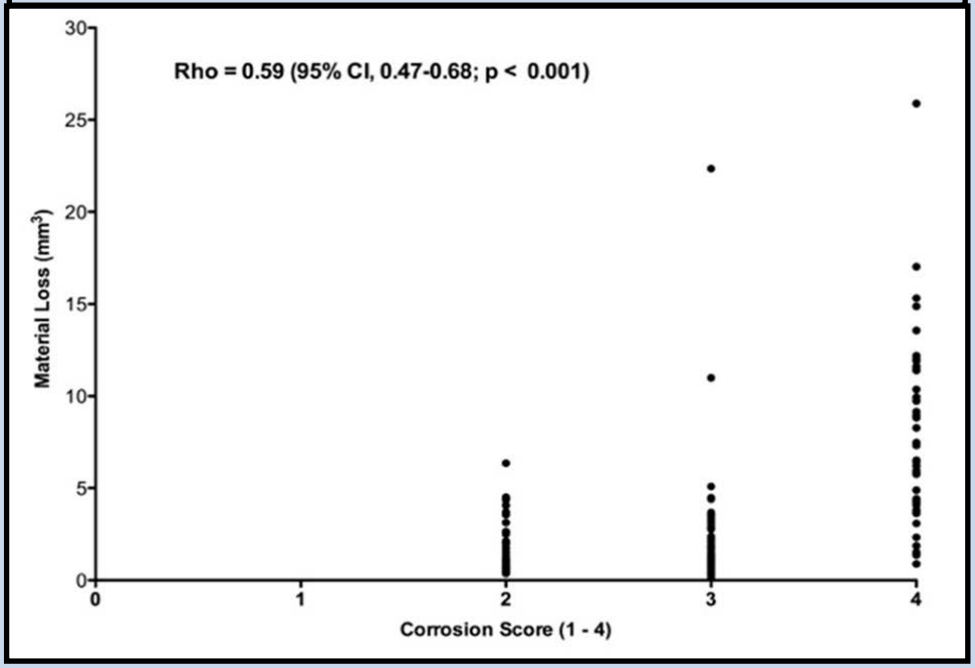
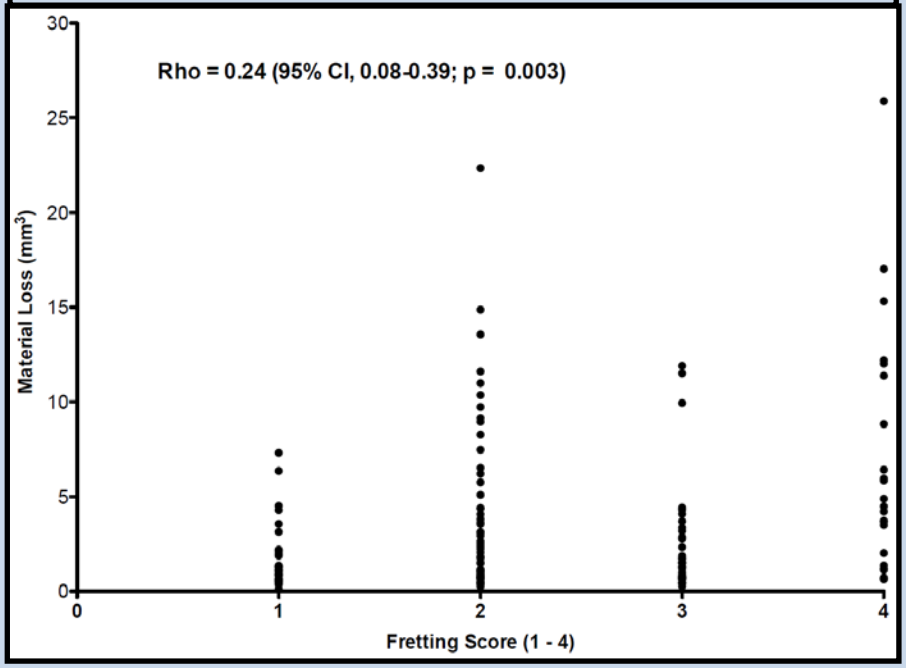
Results

Corrosion



Fretting



- The taper corrosion score was significantly and moderately correlated with the volume of material loss measured.
- The fretting score was also significantly correlated with the volume of material loss, but the correlation was weak.

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Conclusions

1. Detailed visual examination of taper surfaces for the appearance of corrosion can produce reliable data.

2. Visual examination may be able to predict the severity of material loss but is not a substitute for complex metrology methods.

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Thank you

Thank you for your attention

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